Antler rubbing of Yellow-wood by Sambar in East Gippsland, Victoria

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Abstract
Surveys of 49 Warm Temperate Rainforest gullies in East Gippsland identified discrete populations of Yellow-wood *Acronychia oblongifolia* in 34 gullies. Antler rubbing of Yellow-wood by Sambar *Cervus unicolor* was obvious and widespread in all 34 gullies. Eight gullies were randomly selected to assess the extent of antler rubbing to 100 Yellow-wood plants in each gully (50 plants close to two randomly generated locations). Across all eight gullies an average of 64.6% (± 17.7 sd; range 36-92%) of Yellow-wood individuals were antler rubbed, with 51.0% (± 17.8 sd; range 18-80%) subjected to severe rubbing (>50% ringbarking), with mortality recorded at 30.3% (± 14.0 sd; range 6-52%). Yellow-wood with stems in the range 30–150 mm diameter at breast height (DBH) were subjected to the highest rates of antler rubbing (73–81%), with smaller stems (10–16 mm DBH) suffering the highest rates of mortality. Sambar represent a major threat to the long-term persistence of Yellow-wood and rainforest communities in East Gippsland. (*The Victorian Naturalist* **130** (2) 2013, 68–74)

Key Words: *Cervus unicolor*, *Acronychia oblongifolia*, deer, rainforest

Introduction

Sambar *Cervus* (*Rusa*) *unicolor* is a large deer species native to south-east Asia (Bentley 1978; Bilney 2008). During the 1860s they were released into Victoria for recreational hunting purposes, and have since become the most successfully established deer species in Australia, occupying most forested habitats in south-eastern Australia (Bentley 1978; Moriarty 2004; Peel *et al.* 2005; Gormley *et al.* 2011). Its population size and distribution is continuing to increase in south-eastern Australia (Moriarty 2004; Peel *et al.* 2005; Gormley *et al.* 2011), despite considerable recreational hunting effort (estimates of annual legal harvest for 2009–2011 in Victoria were between 28762 and 34368 individuals (Gormley and Turnbull 2010, 2011).

Concern is mounting about the ecological impacts caused by Sambar; however, the extent and severity of their impacts remain poorly understood (Stockwell 2003; Peel *et al.* 2005; Scientific Advisory Committee 2007a; Bennett 2008). In the state of Victoria, Sambar has recently been listed under the *Flora and Fauna Guarantee Act 1988* as a 'potentially threatening process' to biodiversity, while in New South Wales, Sambar, along with all other feral deer species, is listed under the *Threatened Species Conservation Act 1995* as a 'key threatening process' (NSW Scientific Committee 2005; Scientific Advisory Committee 2007a). Yet, in Victoria, Sambar are also listed under the *Wildlife Act 1975* as protected wildlife, due to their status as a highly valued game species. It is therefore illegal to harvest Sambar without a Victorian Game Licence (issued by Department of Primary Industries) or an Authority to Control Wildlife Permit (issued by Department of Sustainability and Environment). Overall, there is a pressing need to develop an effective and appropriate management strategy for Sambar, but this process is hampered by the meagre ecological information that has been gathered on Sambar and their ecological impact in Australia (e.g. Peel *et al.* 2005; Bennett 2008).

Quantifying ecological impacts of Sambar is challenging, especially differentiating between browsing impacts caused by other herbivore species (both native and exotic). This results in conjecture about the extent of their ecological impacts (e.g. Hall and Gill 2005; Bennett and Coulson 2008); however, there is nothing conjectural about the observed impacts caused by antler rubbing because native mammals do not possess antlers. Deer primarily rub antlers on trees to remove velvet from fully grown antlers, for scent marking to define territories, and potentially for strengthening muscles for fighting (Bentley 1978; Gill 1992). Particular plant species are often targeted due to their aromatic properties, size and physical structure, so this activity can result in a considerable impact on some plant species (Kile and Marchinton 1977; Benner and Bowyer 1988; Johansson *et al.* 1995; Bennett and Coulson 2011).

One plant species observed to suffer severe and targeted antler rubbing is the rare and threatened Yellow-wood *Acronychia oblongifolia* (Peel *et al.* 2005; Scientific Advisory Committee 2007b; Peel 2010) (Fig. 1). In Victoria, Yellow-wood is restricted to communities of Warm Temperate Rainforest, Dry Rainforest and Littoral Rainforest at low elevations in the foothills and coastal forests between the Mitchell River and the Bemm River in East Gippsland (an area approximately 150 km in length) (Costermans 1983; Peel 1999). It is a thicket-forming species relying on site occupation by root-suckering once the original seedling has established. As a canopy component, it is generally sparsely and patchily distributed throughout rainforest patches. In some gullies the entire population may number only several hundred individual trees or fewer, while some populations can exceed several thousand (pers. obs.).

The aim of this study was to assess Sambar antler rubbing on Yellow-wood in eight populations throughout the known range of Yellow-wood in Victoria, to evaluate the impacts of Sambar antler rubbing.

Methods

Between 2002 and 2008, most known stands of Warm Temperate Rainforest (based on Ecological Vegetation Class maps available on-line from the Department of Sustainability and Environment http://www.dse.vic.gov.au/about-dse/interactive-maps) were surveyed from foothill and coastal forests (below 400 m elevation) between the Mitchell River in the west and the Snowy River in the east (excluding the Snowy River catchment, but including Cabbage Tree Creek approximately 10 km east of the Snowy River). The survey area incorporated most of the known populations of Yellow-wood in Victoria (except for the Snowy River

Fig. 1. A stand of 17 Yellow-wood, all severely antler rubbed by Sambar.

and Bemm River catchments) (Flora Information System, Department of Sustainability and Environment, Viridans Biological Database: accessed May 2005).

A total of 49 isolated stands of Warm Temperate Rainforest were surveyed and Yellow-wood was detected in 34 (12 sites in the Mitchell River catchment, nine in the Tambo River catchment, two in the Tara Range, 10 in the Lakes Entrance/Lake Tyers area, and one at Cabbage Tree Creek). At all 34 sites, Sambar antler rubbing on Yellow-wood was obvious and widespread. Eight of the 34 sites were randomly selected to assess the extent of antler rubbing on Yellow-wood (three sites from the Mitchell River catchment, two from the Tambo River catchment and three from Lake Tyers). These sites were selected by consecutively numbering all Yellow-wood populations with a number between one and 34 and randomly selecting eight numbers between 1 and 34. Gullies supporting Yellow-wood populations of less than 100 individuals were not analysed.

A total of 100 Yellow-wood stems was assessed for antler rubbing in each gully, and this required assessing the 50 plants closest to two randomly generated locations within each gully. Steep rocky terrain was avoided and all surveys were conducted near the gully floor or on lower slopes of gullies.

For each Yellow-wood stem, the diameter at breast height (DBH) was recorded. However, stumps of Yellow-wood stems (<1 m in height) that had been killed by antler rubbing were measured at their highest point, which was considered to still closely resemble the tree's DBH. Individuals with stem diameters <10 mm or which had died without any apparent sign of antler damage were not assessed. Antler-rubbed Yellow-wood were categorised as either 'Dead' (obviously antler-rubbed with a dead main trunk with or without regenerating basal/coppicing shoots and therefore considered effectively dead) or 'Alive' (with leaves). The extent of antler rubbing was allocated to three categories: 'Severe' where over half of the trunk's outer-bark is removed, 'Moderate' with less than half of the trunk's outer-bark removed, or 'None' (non-rubbed). An assessment of foliage cover was rejected as a measure of tree health primarily because it was apparent that the extent of antler rubbing did not always correlate with tree health. This is because of the differing time since antler rubbing (ranging from several days to several years), and tree health appeared to deteriorate with time since rubbing. The extent of antler rubbing damage to the bark therefore appeared a more consistent measure of antler rubbing impact. Surveys to assess antler rubbing were conducted between 2010 and early 2012.

Statistical procedures including Chi-square tests, Mann Whitney *U* tests and Kruskal-Wallis tests were conducted using SPSS version 16.0 (SPSS Inc, Chicago, Illinois).

Results

A total of 800 individual Yellow-wood stems was assessed for antler rubbing across 16 stands in eight gullies in East Gippsland. Across these sites, an average of 64.6% (± 17.7 sd, range 36-92%) of Yellow-wood stems had been subjected to antler rubbing, with 51.0% (± 17.8 sd, range 18-80%) experiencing severe rubbing or death (Table 1).

Size class of stems rubbed

Sambar antler-rubbed Yellow-wood stems of all sizes (including the largest tree recorded at 312 mm DBH), although the extent of antler rubbing and its impact varied depending on stem diameter (Figs. 2 and 3). Smaller (<30 mm) and larger stems (>150 mm) were subjected to reduced rates of rubbing compared to their availability ($X^2 = 11.379$, df = 5, $p = 0.044$) (Fig. 2), while stem DBH also differed significantly between rubbed (mean; 54 mm ± 4.1 sd) and non-rubbed stems (45 mm ± 5.0 sd) (U = 53,799, $p < 0.001$).

There were significant differences relating to average stem DBH and the extent of rubbing ($H = 55.798$, df = 2, $p < 0.001$), with moderately rubbed stems (76 mm ± 5.5 sd) being larger than severely rubbed stems (alive and dead) (48 mm ± 3.4 sd), which were larger than non-rubbed stems. Severely rubbed dead stems (37 mm ± 2.2 sd) on average had significantly smaller DBH than severely rubbed alive stems (65 mm ± 4.0 sd) (U = 10352, p = <0.001), indicating that larger trees were more resilient to surviving antler damage than smaller trees. The largest dead stem with antler rubbing had a DBH of 127mm. As DBH increased, the sever-

Table 1. The extent of damage caused by Sambar antler rubbing to 16 stands of Yellowwood across eight populations, totalling 800 individuals in East Gippsland.

Plant condition and extent of antler rub damage	%	sd	Range (%)	
			Minimum	Maximum
Alive - None	35.4	17.7	8	64
Alive - Moderate (<50% ringbarked)	13.6	8.5	2	28
Alive - Severe (>50% ringbarked)	20.8	9.1	2	32
Dead - Antler rubbed	30.3	14.0	6	52

ity of antler rubbing declined, along with rates of mortality (Fig. 3).

Discussion

The extent and severity of damage inflicted by Sambar antler rubbing on Yellow-wood is of serious conservation concern. Even the lowest recorded rate of antler rubbing to a single population was high (at 36%), while at the other end of the spectrum, the most severely observed damage (at 92%, with 52% mortality) is of grave concern. Of additional concern is the limited time-frame in which such extensive damage has been inflicted, with Sambar occupying the study area only in the last 50 years (foothill forests) to 25 years (coastal forests) (e.g. Peel *et al.* 2005).

Mortality was the only measure of tree health recorded in this study, primarily because it was apparent that the current health of trees did not appear to be a suitable measure of the trees' long-term health. This was due to the variation in time since trees were rubbed, with recently rubbed trees typically appearing to be in better condition than older rubbed trees. The time to death was likely to be correlated with the degree of ringbarking, with complete ringbarking typically inducing mortality quickly, while many severely and even moderately rubbed plants progressively declined in health, eventually resulting in mortality. Most trees subjected to severe antler rubbing were partially dead with several dead limbs and significantly reduced foliage cover, and many trees were expected to die soon. Some older plants appeared to have died from minimal ringbarking, possibly due to infection from the wound caused by antler rubbing (e.g. Stewart 2001). Undoubtedly, the levels of mortality at these sites will increase progressively over time (irrespective of continued additional antler rubbing), and this study has underestimated the inevitable extent of mortality. Long-term studies on the health of individual rub-trees will be important for evaluating the true extent of mortality induced by antler rubbing.

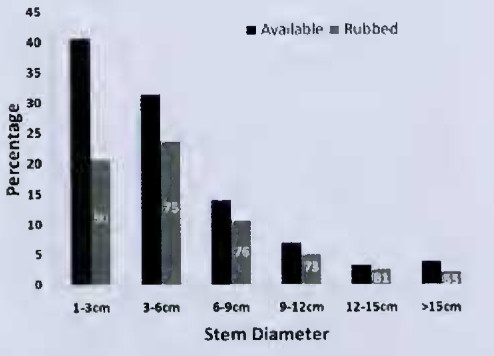

Fig. 2. The availability of Yellow-wood compared with the percentage antler rubbed by Sambar in different size classes. Percentages rubbed are displayed in white.

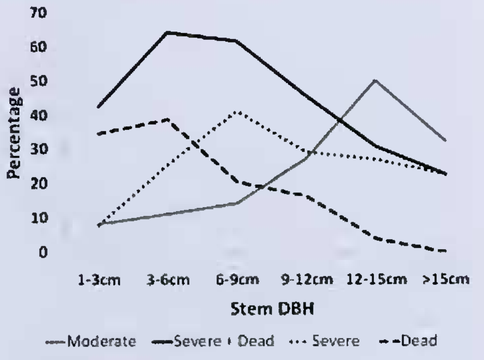

Fig. 3. The percentage frequency and extent of antler rubbing on Yellow-wood of different stem DBH size classes, including the level of mortality (Dead).

Fig. 4. Mortality of both a mature Yellow-wood stem (now a stump) and resprouting stem (horizontal stem), caused by antler rubbing.

Despite the high levels of mortality that are occurring, Yellow-wood trees often re-sprout from stems below antler rubs and/or sucker from roots. Yellow-wood therefore has the potential to persist in areas subjected to high levels of adult stem mortality; however, the regeneration is often subjected to antler rubbing once it reaches suitable size (Fig. 4), so the plant has a limited capacity to reach maturity. Therefore, the short-term ability for Yellow-wood to persist at sites with continued antler rubbing is high, but the long-term survival of Yellow-wood is in doubt given that its primary regenerative mechanism for the renewal of the stand and individual is dramatically affected.

The ecological impact of antler rubbing by Sambar on Yellow-wood trees is not restricted to the individual tree, but includes impacts on the entire plant community (rainforest) in which it grows. This is primarily due to the important role that Yellow-wood, like any rainforest canopy species, provides by facilitating crucial ecological processes within rainforest communities. A combination of mortality and impaired health caused by antler rubbing dramatically reduces foliage cover (e.g. Bennett and Coulson 2011; pers. obs.) and results in increased light penetration to the rainforest floor, affecting moisture retention (rainforest drying), regeneration dynamics, the encroachment of non-rainforest plants, increased susceptibility to fire and potentially rainforest contraction and loss (Peel *et al.* 2005). Of concern is that this is occurring due to antler rubbing alone and irrespective of the impacts caused by heavy browsing pressure (Peel *et al.* 2005). This disruption and prevention of crucial rainforest ecological processes is overwhelmingly apparent at one coastal study site (Lake Bunga) in particular where Yellow-wood dominates the rainforest canopy and there has been a dramatic transformation of the entire stand of rainforest within the past eight years (pers. obs.). At this site, there are only 179 Yellow-wood individuals in the entire gully, and 87.2% have been severely rubbed, resulting in 46% mortality. The rainforest communities that exist at this site include Littoral Rainforest (listed as Critically Endangered under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999*).

Several animal species are likely to be affected by Sambar damage to Yellow-wood. Yellow-wood fruits in some years only (possibly correlating with rainfall or moisture), usually in late spring or early summer. Several bird species consume the fruit and aid in seed dispersal (e.g. Satin Bowerbird *Ptilonorhynchus violaceus*, Pied Currawong *Strepera graculina*), including the migratory Topknot Pigeon *Lopholaimus antarcticus* that reaches its most south-western distribution limit in this study area (e.g. Barrett *et al.* 2003). Fruiting Yellow-wood is likely to provide an important food source for the Topknot Pigeon, since in years when Yellow-wood fails to fruit, Topknot Pigeons are rarely observed in the study area (pers. obs.). Reduced fruiting as a consequence of antler rubbing will result in reduced food for these species.

The Yellow-spotted Jezebel *Delias nysa* is another rainforest-dependent species that reaches its most south-western distribution limit in East Gippsland (recorded east of Lakes Entrance) (Braby 2000; Peel 2010). Adults have been observed feeding on the nectar of Yellow-wood and using the trees as a focus for social activity prior to mating (Peel 2010). Their larvae feed exclusively on the stems of Jointed Mistletoe *Korthalsella rubra*, a species restricted to rainforest (Braby 2000; Peel 2010).

Rainforest provides dense foliage cover suitable as roosting sites for the threatened Sooty Owl *Tyto tenebricosa* and Powerful Owl *Ninox strenua* (Bilney *et al.* 2011). Both owl species have been recorded roosting in and near Yellow-wood trees (Bilney *et al.* 2011). Four recorded roost trees in Yellow-wood (from a total of six) have subsequently been antler-rubbed by Sambar, resulting in reduced foliage cover and abandonment of these trees as roosting sites (pers. obs.). Four additional roosting sites in other rainforest canopy species located near Yellow-wood trees also appear to have been abandoned following rubbing and mortality (or reduced foliage cover) of nearby Yellow-wood trees (pers. obs.).

Studies of antler rubbing by other deer species reveal that Yellow-wood seems to possess several characteristics that are preferred for antler rubbing, including stem DBH, smooth bark, considerable height to first branch and aromatic properties (Kile and Marchinton 1977; Benner and Bowyer 1988; Johansson *et al.* 1995). Yellow-wood is a particularly aromatic species, from the family Rutaceae, and another member of the family targeted by Sambar for antler rubbing includes the threatened Shiny Nematolepis *Nematolepis wilsonii*, which is restricted to two populations in the upper Yarra River catchment (Bennett and Coulson 2011).

It should be noted that Yellow-wood can grow at rainforest margins in mid to upper slopes of rainforest gullies and in steep rocky areas, yet this study targeted only gully floor environments. Therefore, the extent of antler rubbing documented in this paper may not represent the extent of antler rubbing that is occurring throughout Yellow-wood stands. For example, some large stands of Yellow-wood exist that have been subjected to only minimal antler rubbing. On the other hand, there are also sites, especially small stands, where damage is more severe (e.g. one stand of 32 trees has suffered 100% mortality).

Management

The magnitude of the impact of Sambar on Yellow-wood and rainforest communities warrants immediate conservation management attention. This urgency is increasing as the population and distribution of Sambar continue to expand. Unfortunately, currently there is no feasible management option available for reducing the ecological impacts of Sambar on the scale that is warranted. Exclusion fencing is only feasible for small isolated stands of Yellow-wood, due to the the scale, expense and practicality of fencing that is required. Targeted hunting at particular sites again is neither feasible nor effective due to the scale of the threat. Hunting, especially of dominant stags, could potentially result in the disruption of territories and increase territorial disputes, resulting in increased sign marking by subordinates and thus result in increased rub damage. Lethal management options that target females would therefore be preferred.

Overall, there is an urgent need to reduce the population density of Sambar across the landscape. This will require research into control options, as well as increasing our understanding of their general biology and ecology in Australian ecosystems. Identifying and implementing effective control methods for Sambar may represent one of the greatest challenges facing land managers and conservation agencies.

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